11-1985

B811: Field Appraisal of Resource Management Systems Farms Crop Yield and Quality Relationships with Soil Erosion - 1982

Paul R. Hepler

Lauren H. Long

Kenneth J. LaFlamme

John H. Wenderoth

ISSN 0734-9556

FIELD APPRAISAL OF RESOURCE MANAGEMENT SYSTEMS *FARMS*

Crop Yield and Quality Relationships with Soil Erosion — 1982

Paul R. Hepler
Lauren H. Long
Kenneth J. LaFlamme
John H. Wenderoth

MAINE AGRICULTURAL EXPERIMENT STATION
University of Maine at Orono
Orono, Maine 04469
In Cooperation With:
SOIL CONSERVATION SERVICE
U. S. Department of Agriculture

Bulletin 811 Nov 1985

FIELD APPRAISAL OF RESOURCE MANAGEMENT SYSTEMS *FARMS*

Crop Yield and Quality Relationships with Soil Erosion—1982

Paul R. Hepler
Lauren H. Long
Kenneth J. LaFlamme
John H. Wenderoth

MAINE AGRICULTURAL EXPERIMENT STATION
University of Maine at Orono
Orono, Maine 04469
In Cooperation With:
SOIL CONSERVATION SERVICE
U. S. Department of Agriculture

Bulletin 811 Nov 1985

Acknowledgement

Field Appraisal of Resource Management Systems
FARMS
SPONSORED BY:

Central Aroostook Soil and Water Conservation District
St. John Valley Soil and Water Conservation District
Southern Aroostook Soil and Water Conservation District
St. John-Aroostook RC&D Steering Committee

In cooperation with:

USDA Soil Conservation Service
USDA Economics Research Service
University of Maine: Maine Agricultural Experiment Station (with Hatch support) and Department of Plant and Soil Sciences
Maine Department of Agriculture, Food, and Rural Resources

Directed by the Farms Steering Committee

Richard D. Babcock, State Soil Scientist
USDA Soil Conservation Service
Mark R. Bailey, Agricultural Economist
USDA Economics Research Service
Barton M. Blum, Project Leader USDA
USDA Forest Service
Walter J. Grant, Research Soil Scientist
USDA Agricultural Research Service
Ronald E. Hendricks, State Conservationist
USDA Soil Conservation Service
Paul R. Hepler, Associate Professor of Horticulture
University of Maine
Lauren H. Long, State Resource Conservationist
USDA Soil Conservation Service
(Committee Chairman)
Frank Ricker, Executive Director
Maine Soil and Water Conservation Commission
Robert V. Rourke, Senior Soil Scientist
University of Maine

Field Appraisal of Resource Management Systems
FARMS

Crop Yield and Quality Relationships with Soil Erosion — 1982

Paul R. Hepler
Lauren H. Long
Kenneth J. LaFlamme
John H. Wenderoth

ABSTRACT

This document presents the objectives and third-year results of the Field Appraisal of Resource Management Systems (FARMS) study. The principal objectives of FARMS were to study the relationship of crop yields to predicted soil erosion and to simulate the economics of this relationship. Crop management, soils, conservation practices and management, crop yields, soil chemistry, and sociological data were collected. The data analyzed in preparing this report are from the 800 plots sampled in 1982. This report presents statistics for rill and sheet soil erosion, which is estimated by the Universal Soil Loss Equation (USLE) and assumed to represent a long term rather than short term effect. The report also presents summary statistics for each of the factors in the USLE: for potato yields and quality, for yields of four other field crops, and for soil nutrient analyses.

No general response of potato yield and quality to predicted soil erosion was found. However, interaction between potato variety and predicted soil erosion was significant. Potato yields were significantly related to the conservation practice (P), with higher yields associated with cross slope row orientation. Potato yields were significantly reduced when the previous crop was potatoes or grain in comparison to hay.

INTRODUCTION AND LITERATURE REVIEW

Soil erosion is a major problem on land planted to row crops in Aroostook County, Maine, which is one of the most intensively farmed areas in the United States. During recent years, a major portion of this cropland area has been planted to potatoes. Ninety eight thousand acres of potatoes were planted in 1982.

Soil erosion has an immediate and a long range effect. Of immediate concern is the damage caused by transported soil particles which contribute to the sediment load and pollution of surface water. Water is polluted by the soil particles themselves and also by agricultural chemicals adsorbed on transported soil particles. A future as well as immediate concern is the loss of productivity due to the cumulative effects of soil erosion. The USLE is used to predict average annual sheet and rill erosion soil losses from a particular cropland area (16). The USLE formula is:

$$A = R \times K \times LS \times C \times P,$$

where A is soil loss in tons per acre per year; R is the rain and snowfall factor; K is soil erodibility; LS is the topographic factor (length and steepness of slope); C is cover and management; and P is the conservation practice factor.

The USLE equation does not measure soil losses for a particular year; rather, it predicts average annual soil losses. Furthermore, the USLE does not predict how much soil ends up in a lake or stream. It predicts how much soil erodes from a particular field or area of a field.

The concern about soil erosion in Aroostook County is due to the potential consequences for the agricultural industry if the present high rates of erosion continue. The Study of Non-Point Agricultural Pollution (SNAP) estimated that the average annual rate of soil erosion was between 5.2 and 6.3 tons per acre per year for land in row crops during the years 1979 to 1983 (2). Soil loss of 3.0 tons per acre per year is considered "tolerable" for most Aroostook County soils since natural soil formation will replace such loss. This tolerable rate of erosion, T, serves as a practical means for identifying areas most in need of conservation treatment.

Conservation practices have been applied in Aroostook County to varied degrees over the past 40 years. These practices address one or more of the factors contributing to the rate at which cropland erodes. However, only 41 percent of cropland has been adequately treated (3).

This bulletin presents preliminary analyses of the 800 plots sampled in 1982. It is the fourth in a series of six reports which will eventually summarize the FARMS data collection and analysis work. The first report in this series describes data collection methods (5), and the second and third present the summary analyses for 1980 and 1981 (10,11). A summary of all three years and a report concerning the economics of erosion consequences and control are scheduled for publication in the near future.

OBJECTIVES AND ASSUMPTIONS OF "FARMS"

The Field Appraisal of Resource Management Systems (FARMS) study was initiated to address two general objectives. The first concerns the relationship of crop yield and quality to predicted soil erosion rates, conservation management, crop management, soil and soil fertility. The impact of soil erosion on crop yield and quality is examined by using erosion rates predicted by the USLE. This impact on crop yields is assumed to represent past, long-term erosion effects. Erosion phases (15), a more traditional long-term indicator of erosion, cannot be consistently measured for the thinly developed, deeply disturbed soils of this Major Land Resource Area, MLRA 146.

The second general objective of the FARMS study is to identify those conservation practices or combinations of practices providing maximum economic benefits while protecting the resource base. Evaluating the effects of different combinations of practices on net farm income should help farmers to make informed choices in controlling erosion. Farmers, bankers, and legislators should also be better able to assess the long-term value of investments in conservation.

This report is designed to answer the following specific questions raised at both the state and national levels during the recent Resources Conservation Act (RCA) process - a process designed to make soil and water conservation efforts more efficient and effective.

1 Is there a relationship between predicted amounts of soil erosion and crop production?
2 Is there a relationship between predicted rates of soil erosion and crop quality?
3 Do conservation rotations improve crop quality and increase crop yields, and, if so, to what extent?
4 What are the effects of soils on crop yields?
5 What soils are being used for crop production in Aroostook County?
6 Can increased rates of fertilizer offset productivity loss caused by soil erosion?
7 Do some varieties of potatoes produce better yields and quality with similar management practices on the same soils?

The FARMS study assumed that over several decades the farmers in Aroostook County have carried out a wide array of conservation management from very good to very poor. It is also assumed that the conservation management observed at the time of the study reflects the past history of conservation management. It is further assumed that the USLE (16) adequately assesses the levels of soil erosion and conservation management for estimating their effects on potato yield and quality.

METHODS

The FARMS study area is located primarily within MLRA 146 and is almost entirely within Aroostook County in northeastern Maine. Four townships in northern Penobscot County, which are included in the Southern Aroostook Soil and Water Conservation District, are also within the Project Area. The FARMS study encompasses 2,721,733 acres with about 9 percent of the FARMS study area used for row crops. Significant acreages of oats, hay and peas are grown in rotation with the major crop, potatoes. Most of the remaining land is forest or idle land that is being allowed to revert to forest. The topography, rainfall, climate, and soils have been described by Arno (6,7) and in previous bulletins of this series (5,10,11).

Twenty four hundred experimental plots were selected through a two stage randomization, with 300 eighty acre blocks and eight plots per block. Eight hundred plots were studied each year. Plot size for crop yields was 43.56 square feet, or 1/1000 acre (5).

The data collected for the FARMS study fall into six major categories: soils, crop history, conservation practice, crop management, crop yields, and sociological information of the farm managers.

Soil samples collected from each plot were analyzed for 10 nutrients using pH 3.0 ammonium acetate (8), Walkley-Black organic matter (13), water pH (13), exchangeable cations by pH 7.0 ammonium acetate (13), potassium chloride acidity (13), and barium chloride-triethanolamine acidity (13) by the analytic laboratory of the Department of Plant and Soil Sciences, UMO.

The SAS statistical package was used for all data analyses (14). Covariance procedures were employed with the 5 percentage level for significance. Treatment means were adjusted through the least squares procedure. Percentage data, except for Table 10, were transformed to angles for variance analyses and determination of significant differences. These means were then retransformed to percentage for presentation in the tables.

RESULTS AND DISCUSSION

Soils and Soil Erosion

Table 1 shows the distribution of plots by soil, soil and water conservation district (SWCD), and prime farmland. Forty two percent of the plots are on Caribou soil. Four soils, Caribou, Conant, Chesuncook, and Mapleton constitute 66 percent of the 1982 plots. It should also be noted that few if any of the soils are proportionally represented in the three SWCD's.

Seventy four percent of the plots was located on prime farmland. This is an increase of 9 percent from 1981 signifying a possible movement toward

Table 1. Distribution of Plots by Soil, Soil and Water Conservation District, Prime Farmland, Soil Erodibility, (K), and Tolerable Soil Loss (T), FARMS, 1982.

SOIL	Number of Plots Tot	StJ	Cen	Sou	Prime Farm-land	K	T
Caribou	335	5	248	82	304	0.26	3
Conant	77	3	63	11	72	0.30	3
Chesuncook	61	36	16	9	36	0.32	3
Mapleton	52	0	36	16	36	0.32	2
Perham	38	0	37	1	35	0.26	3
Masardis	32	16	16	0	0	0.11	3
Elliottsville	30	12	7	11	29	0.17	3
Telos	25	13	8	4	0	0.26	3
Monson	23	10	2	11	0	0.17	2
Plaisted	23	18	3	2	12	0.28	3
Daigle	17	1	14	2	0	0.27	3
Stetson	13	5	8	0	13	0.11	3
Winnecook	12	6	0	6	10	0.22	3
Allagash	9	5	4	0	9	0.21	3
Bangor	8	5	2	1	6	0.20	3
Madawaska	5	1	4	0	5	0.21	3
Monarda	5	5	0	0	0	0.25	3
Nicholville	5	4	1	0	3	0.46	3
Howland	4	2	1	1	3	0.22	3
Lovewell	4	4	0	0	4	0.32	5
Skowhegan	4	0	4	0	0	0.12	3
Roundabout	3	3	0	0	0	0.38	3
Berkshire	2	0	2	0	2	0.22	3
Cornish	2	2	0	0	0	0.32	5
Easton	2	0	0	2	0	0.23	3
Fryeburg	2	0	2	0	2	0.29	5
Thorndike	2	1	0	1	0	0.18	2
Danforth	1	1	0	0	1	0.24	3
Lyman	1	1	0	0	0	0.20	2
Machias	1	0	1	0	1	0.14	3
Podunk	1	0	1	0	1	0.16	3
Rumney	1	1	0	0	0	0.28	3
Total	800	160	480	160	592		

SWCD's: StJ=St. John Valley, Cen=Central Aroostook, Sou=Southern Aroostook.

increased dependence on prime farmland. Prime farmland has the best combination of physical and chemical characteristics for producing food.

An estimate of tolerable soil loss T is also presented in Table 1. T represents the amount of soil loss in tons per acre per year that can be experienced without reducing the long term agricultural productivity of the soil. The soils in the FARMS study area will not tolerate appreciable soil erosion as evidenced by the fact that all but 10 plots have T values of three or less.

The individual factors of the USLE were either measured or estimated for each of the 800 plots. The means and variability for A and the individual USLE factors K, LS, C, and P are given in Table 2. The 1982 average estimated soil loss was 3.77 tons per acre per year, with a large standard deviation and coefficient of variation. The average estimated soil loss in 1982 was almost a ton less than was observed in 1980, and considerably less than the 6.2 and 5.7 tons per acre for Aroostook County in the 1979 and 1982 SNAP inventories (1,2). The distribution of plots by increments of predicted erosion, A, is given in Table 3. This distribution is skewed with half the plots having A levels less than 2.57 tons per acre per year and the other half ranging from 2.57 to 35 tons of soil loss per acre per year. Since T, the tolerable soil loss, is 3 tons for most of the soils in the study area, 45 percent of the plots need additional conservation treatment. The factor R for the entire study area was 75 and, therefore, does not affect the calculation of A from one plot to another. For Tables 2 and 3 the two components of LS were measured from

Table 2. Summary Statistics for Estimated Soil Loss (A) in Tons Per Acre, and for Selected Factors of the Universal Soil Loss Equation, 800 Plots, FARMS, 1982.

Statistic	A	K	L	S	LS	C	P
Mean	3.77	0.25	433	4.73	0.97	0.23	0.91
St.Dev.	3.73	0.06	290	2.55	0.77	0.09	0.12
CV	99	24	67	54	80	37	13
Maximum	34.57	0.54	2300	15	5.26	0.45	1.00
Quartile-3	4.88	0.28	600	6	1.36	0.28	1.00
Median	2.57	0.26	350	4	0.73	0.23	1.00
Quartile-1	1.36	0.23	225	3	0.40	0.17	0.80
Minimum	0.04	0.02	25	1	0.13	0.01	0.38

A = Estimated Soil Loss in tons per acre per year; K = Soil Erodibility Factor; L = Length of Slope Feet; S = Steepness of Slope in Percent; LS = Topographic Factor; C = Soil Cover and Mangement Factor; P = Conservation Practice Factor; St. Dev. = Standard Deviation; CV = Coefficient of Variation the point of overland flow, through the plot, to the point of deposition or interception. For subsequent analyses that relate potato yield and quality to the USLE, the components of LS were measured from the point of overland flow to the plot. This was done to reduce variability due to slope length segments below the plot (and therefore total estimated erosion) that was unrelated to the erosive force of water at the plot. Only the erosive force of water from the slope length segment above the plot was assumed to directly affect the productivity loss due to erosion at the plot.

Table 3. Distribution of the 1982 FARMS Plots by Increments of Erosion as Predicted by the Universal Soil Loss Equation, through the Plot Measurements for L and S, FARMS, 1982.

Predicted Erosion	Number of Plots	Percent of Plots
0.00-1.00	124	15.5
1.01-2.00	198	24.7
2.01-3.00	122	15.3
3.01-4.00	104	13.0
4.01-5.00	56	7.0
5.01-6.00	46	5.8
6.01-7.00	38	4.7
7.01-8.00	26	3.2
8.01-9.00	21	2.6
9.01-10.00	14	1.8
10.01-15.00	39	4.9
15.01-20.00	7	0.9
20.01-25.00	1	0.1
25.01-30.00	3	0.4
30.01-35.00	1	0.1
Total	800	100.0

The K values assigned for each soil from the Maine Technical Guide Handbook (4) were adjusted according to the soil texture and content of rock fragments as described for each individual plot. The average adjusted K values vary by soil from 0.11 for Masardis and Stetson to 0.46 for Nicholville, Table 1. The Caribou, Conant, Chesuncook and Mapleton soils, which comprise 525 of the 800 plots, all have average K values that range from 0.26 to 0.32, and are somewhat higher than the weighted average of 0.25 for all plots. The practice of removing rocks from the fields to facilitate tillage and potato harvest increases soil erodibility.

The conservation practice factor, P, had a limited variability, with 62 percent of the plots having the maximum P value of 1.00 and 98 percent of the plots had P values ranging from 0.75 to 1.00, Tables 2 and 4. Direction of rows in relation to the slope is a primary determinant for establishing the value of P. Row direction was up and down the slope for 361 plots. Thus, 45 percent of the plots had the row direction affording the poorest protection (P=1.00) against erosion. Cross slope farming, 405 plots, affords some protection (P=0.75 to 0.95) against erosion. However, strip-cropping and contour stripcropping which provide better protection were represented by only 19 plots. Diversions and waterways constructed in conjunction with contour stripcropping provide the best protection. Increased use of stripcropping and grassed waterways would result in lower P values and reduced erosion. The practice of planting up and down the slope may be partly intended to prevent extended periods of ponding or flooding, which potatoes do not tolerate. It may also result from efforts to maximize the efficiency of field operations by orienting rows with the longer dimension of the field.

Table 4. Distribution of Plots by Conservation Practice Factor (P), FARMS, 1982.

Conservation Practice	Number of Plots	Percent of Plots
0.38	1	0.1
0.50	4	0.5
0.56	1	0.1
0.60	6	0.8
0.75	183	22.9
0.80	109	13.6
1.00	496	62.0
Total	800	100.0

Crop History

Table 5 presents typical C values for rotations replicated on 10 or more plots. The average C value is 0.23, with a normal distribution about this mean ranging from 0.01 to 0.45, Table 2. C represents the relative soil cover or protection provided by plant material. It can be seen from Table 5 that choice of rotation has a major impact on C values. Continuous potatoes (P) and Potatoes-Peas (PPe) leave the soil exposed to the impact of falling rain, as well as the movement of running water, particularly in comparison to rotations that include grain and hay (e.g., PG and PGH), which afford better average cover during the rotation cycle.

Table 5. Principal Rotations, FARMS, 1982.

Rotation	Typical C Values	Number of Plots	Percent
PG	0.24	190	23.8
PPG	0.31	170	21.3
PPGH	0.21	113	14.1
PPPG	0.34	75	9.4
P	0.44	49	6.1
PPPe	0.46	20	2.5
PGPPe	0.36	17	2.1
H	0.004	17	2.1
Pe	0.47	16	2.0
PPPH	0.29	15	1.9
PPHH	0.20	13	1.6
PGHH	0.11	13	1.6
PPGG	0.25	11	1.4
GGHH	0.05	11	1.4
PPPeG	0.38	10	1.2
PGG	0.22	10	1.2
Miscellaneous		50	6.3
Total		800	100.0

P=potatoes, G=grain and buckwheat, H=hay-pasture, Pe=peas

Distribution of the crops by conservation district is given in Table 6. Over all districts, potatoes were grown on 64 percent and oats on 20 percent of the plots. Hay and pasture were disproportionately concentrated in the St. John Valley and Southern Aroostook SWCD where a majority of the livestock is found. Peas, a crop of variable acreage from year to year, occurred only in the Central Aroostook SWCD.

Crop Yield

Yields from seven different crops were obtained in 1982, four of which are given in Table 7. Oat yields were a third lower in 1982 than in 1980 or 1981. Yields for hay and peas were comparable to the previous two years.

Gross yields of potatoes, Table 8, were somewhat higher in 1982 than in 1980 or 1981. The percentage of US-1 potatoes was 64, which was lower than either previous year, resulting in US-1 yields comparable to 1980 but about 30 hundredweight less than for 1981. The lower percentage of US-1 potatoes

Table 6. Number of Plots by Crop and SWCD, FARMS, 1982.

Crop	Conservation District			Total
	St.John	Central	Southern	
Potatoes	83	341	84	508
Oats	36	85	40	161
Hay-Pasture	40	25	28	93
Peas	0	22	0	22
Buckwheat	1	5	0	6
Barley	0	0	3	3
Millet	0	1	2	3
Rye	0	0	3	3
Wheat	0	1	0	1
Total	160	480	160	800

Table 7. Yields for Crops other than Potatoes, FARMS, 1982.

Statistic	Net Yield in Pounds Per Acre			
	Oats	Hay	Peas	Buckwheat
Mean	1203	3727	3113	474
St. Dev.	482	1605	1165	869
CV	40	43	37	183
Maximum	2875	7690	5020	2243
Quartile-3	1500	4673	4123	733
Median	1188	3345	2995	130
Quartile-1	885	2700	2153	130
Minimum	77	568	1430	50
No. of Plots	145	72	22	6

was due primarily to the variety Russet Burbank. Since the primary russet market is processing which accepts grades US-1, US-2, and oversize, these three grades were combined for yield estimates, Table 8. Specific gravity was the same as for the previous two years. Considerable variability found in yields for all crops indicates a major opportunity for many farmers to improve yields.

Table 8. Summary Statistics for Potato Yield and Quality, FARMS, 1982.

Statistic	Gross cwt	US-1&2 cwt	US-1&2 Pct	Specific Gravity
Mean	323	232	71	1.076
St. Dev.	81	74	13	0.007
CV	25	32	19	0.670
Maximum	522	447	96	1.091
Quartile-3	378	284	83	1.081
Median	331	229	74	1.076
Quartile-1	271	183	62	1.070
Minimum	16	11	27	1.057
No. of Plots	499	499	499	494

The 499 potato plots were distributed unequally among 14 varieties and 23 soils. Since many of these varieties and soils were inadequately represented, a dataset, 7VAR-10SOIL, was formed containing seven varieties on the ten most frequently occurring soils, Table 9. However, this dataset still lacks representation for 20 of 70 variety-soil combinations and is inadequately represented for many other combinations.

Percentage of potatoes by grade for the seven principal potato varieties is presented in Table 10. The two russet varieties are lower in grade US-1 than the five round white varieties. Atlantic had a few US-2 potatoes; otherwise, the round white varieties were comparable, except that Superior was lower in culls. The off-grade BelRus potatoes were almost all small tubers. Russet Burbank graded very low in US-1, and high for US-2, undersize, and culls. Oversize constituted less than 0.5 percent for any variety. The three grades US-1, US-2, and oversize were combined for data analyses since the inclusion of the two extra grades with US-1 would not materially affect the round white yields, and would more nearly reflect market reality for the russet varieties.

Yields for the seven varieties are presented in Table 11. Large significant differences were found among varieties, particularly for yield of US-1&2, percent US-1&2, and specific gravity. The russet varieties had the highest specific gravity, although Atlantic was their equal. Variability among the other four round white varieties was significant. Kennebec and Superior were intermediate in specific gravity, while Ontario and Katahdin were lowest. Kennebec and Superior varieties yielded best in US-1&2. BelRus would require a considerable premium at the market place to compensate for

Table 9. Plot Distribution of the Seven Potato Varieties and Ten Soils, 7VAR-10SOIL Dataset with the Highest Frequencies, FARMS, 1982.

	Variety							
Soil	RB	Su	Kat	Ont	Ken	Bel	Atl	Total
Caribou	58	45	44	26	11	8	7	199
Conant	20	8	10	7	3	1	1	50
Chesuncook	13	6	4	15	0	0	1	39
Mapleton	12	11	3	1	4	2	0	33
Perham	16	3	2	4	0	0	0	25
Elliottsville	4	3	3	6	0	0	2	18
Masardis	4	1	4	6	0	2	0	17
Monson	6	7	0	3	0	0	1	17
Telos	6	0	2	3	0	0	0	11
Plaisted	3	5	0	1	0	1	0	10
Total	142	89	72	72	18	14	12	419

RB=Russet Burbank; Su=Superior; Kat=Katahdin; Ont=Ontario; Ken=Kennebec; Bel=BelRus; Atl=Atlantic

Table 10. Percentage of Potatoes by Grade, 7VAR-10SOIL Dataset, FARMS, 1982.

	Number of	Percent			
VARIETY	Plots	US-1	US-2	Undersize	Cull
Superior	89	82	1	10	8
Kennebec	18	80	0	7	13
Atlantic	12	73	6	10	11
Katahdin	72	75	0	8	17
Ontario	72	72	0	11	17
BelRus	14	67	1	29	3
Rus.Burb.	142	38	23	19	20

its low yields. The low US-1&2 yield of Russet Burbank was the result of a very large pick-out: 19 percent undersize and 20 percent culls.

Potato yields and quality associated with soils for the 7VAR-10SOIL dataset are presented in Table 12. No significant differences among soils were found for gross yield, US-1&2 yield, percent US-1&2, or specific gravity.

Table 11. Yield and Quality of Potatoes as Related to Variety, 7VAR-10SOIL Dataset, FARMS, 1982.

VARIETY	Number of Plots	Yield--cwt Gross		Yield--cwt US-1&2		US1&2 Pct		Specific Gravity	
Kennebec	18	326	abc	267	a	82	a	1.074	b
Superior	89	310	bc	259	a	83	a	1.076	b
Atlantic	12	319	abc	256	ab	80	ab	1.081	a
Ontario	72	333	ab	239	ab	72	c	1.069	c
Katahdin	72	291	c	221	b	76	b	1.067	d
Rus.Burb.	142	354	a	220	b	62	d	1.081	a
BelRus	14	216	d	144	c	67	cd	1.081	a

Table 12. Yield and Quality of Potatoes as Related to Soil, 7VAR-10SOIL Dataset, FARMS, 1982.

Soil	Number of Plots	Yield--cwt Gross	Yield--cwt US-1&2	US-1&2 Pct	Specific Gravity
Mapleton	33	335	250	75	1.076
Masardis	17	311	246	79	1.078
Caribou	199	321	244	76	1.076
Perham	25	331	238	74	1.074
Monson	17	312	237	75	1.074
Chesuncook	39	294	223	75	1.076
Conant	50	306	220	73	1.075
Plaisted	10	302	220	75	1.077
Elliottsville	18	284	219	77	1.075
Telos	11	273	196	71	1.076
		ns	ns	ns	ns

Significant differences were associated with geographic location. The highest yields were in the Southern Aroostook SWCD, while the Central Aroostook and the St. John Valley SWCD's were the same, Table 13. No differences in specific gravity existed among the three districts. Latitude and climate might account for the better yields in the Southern Aroostook SWCD, since the growing season is a little longer and temperatures are somewhat higher. The disproportionate distribution of varieties and soils among the three SWCD's, Table 14, does not seem to account for the yield differences.

Table 13. Yield and Quality of Potatoes by SWCD, 7VAR-10SOIL Dataset, FARMS, 1982.

SWCD	Number of Plots	Yield—cwt Gross	Yield—cwt US-1&2	US-1&2 Pct	Specific Gravity
St. John Valley	66	287 b	220 b	77 a	1.076
Central	289	299 b	218 b	73 b	1.076
Southern	64	336 a	25 a	75 ab	1.075
					ns

Table 14. Plot Distribution of the Seven Principal Potato Varieties and Ten Soils in the Three SWCD's of Aroostook County, FARMS, 1982.

Variety or Soil	Conservation District St. John	Central	Southern	Total
Variety				
Russet Burbank	21	18	3	142
Superior	6	48	35	89
Katahdin	7	55	10	72
Ontario	29	39	4	72
Kennebec	0	17	1	18
BelRus	3	3	8	14
Atlantic	0	9	3	12
Total	66	289	64	419
Soil				
Caribou	3	162	34	199
Conant	0	44	6	50
Chesuncook	25	11	3	39
Mapleton	0	27	6	33
Perham	0	24	1	25
Elliottsville	9	4	5	18
Masardis	11	6	0	17
Monson	8	2	7	17
Telos	5	6	0	11
Plaisted	5	3	2	10
Total	66	289	64	419

Soil Erosion and Potato Yields

Several datasets consisting of different combinations of varieties and soils were studied to determine the relationship of potato yield and quality to estimated soil erosion. The individual factors making up the USLE were also analyzed to determine their relationship to yield and quality. Particular attention was paid to a Four Variety-Seven Soil (4VAR-7SOIL) dataset which provided some replication for all but two of the 28 variety-soil combinations. This dataset consisted of 338 plots for the Superior, Russet Burbank, Katahdin and Ontario varieties on the Caribou, Conant, Chesuncook, Mapleton, Perham, Elliottsville and Masardis soils, Table 9. The 4VAR-7SOIL dataset did not exhibit significant decreases in yield associated with estimated erosion.

The USLE is a multiplicative equation which estimates soil loss (A) in tons/acre/year from the product of five independent factors (16). Therefore, the contribution of each of the individual factors to the estimate of A can be separately evaluated. All possible simple correlations among the factors, and between each of the factors and A, are presented in Table 15 for the 499 potato plots. The correlation data show that A is primarily a function of LS, the topographic factor. A further breakdown of LS showed that steepness of slope (S) is the primary component of LS which accounts for the determination of A. P and C are also contributing significantly to A, but their main effect contributions are much smaller. The relatively low correlations among the factors LS, C, K, and P show that they are acting independently of each other in this set of 499 potato plots.

Table 15. Simple Correlations among A and the Individual USLE Factors, Potato Plots, FARMS, 1982.

USLE Factor	LS	C	K	P
A	0.82*	0.23*	0.11*	0.40*
LS		-0.05	-0.16*	0.26*
C			0.07	0.20*
K				0.04

*Significant p=0.05, n=499.

Since each of the USLE factor acts independently in determining A, predicted erosion, it is possible to study their individual effects on potato yield and quality. No yield and quality responses to either the topographic factor LS, or the soil erodibility factor K were observed.

Yield was significantly related to P, the conservation practice factor. Higher yields were associated with the P value of 0.75, while lower yields were associated with the higher P values, Table 16. These data indicate that better yields are associated with cross slope row orientation in comparison with up and down slope row direction. This is a USLE factor under direct control of the farm operator and would also contribute to decreased soil losses and improved moisture conservation in addition to improved yields.

Table 16. Yield and Quality of Potatoes as Related to the USLE Conservation Practice Factor P, 4VAR-7SOIL Dataset, FARMS, 1982.

P	Number of Plots	Yield—cwt Gross	Yield—cwt US-1&2	US-1&2 Pct	Specific Gravity
0.75	99	349 a	264 a	77 a	1.073
0.80	54	337 ab	234 b	72 b	1.072
1.00	184	326 b	240 b	75 ab	1.074
					ns

Potato yields and specific gravity did not respond significantly to C, the cover and management factor. Ontario exhibited a negative response for percent US-1&2 to increasing C values while the varieties Russet Burbank, Superior, and Katahdin did not show a relationship to the C factor.

Since C is determined by such practices as rotation and type and time of tillage, it is under direct control of the farm operator and, therefore, subject to management changes. These cultural practices may affect yield directly and for reasons other than their indirect influence on the rate of erosion. This prompted the examination of the relationship of potato yields to specific rotations. The first five rotations in Table 5 are the most common and also provide a set of rotations with increasing intensity of potato production.

The effects of rotation on the yield and quality of potatoes are presented in Table 17. In 1981 a decrease in yield was associated with increasing intensity (percentage of years) of potatoes in the rotation. The 1982 results are not as clear. The PPGH rotation did have the best yield and percentage of US 1& 2 potatoes. However, the PG rotation was unexpectedly at the bottom of the list for yield, while the other rotations contributed to the confusion.

The effect of the previous crop in the rotation on the yield and quality of a subsequent potato crop was also studied. The 4VAR-7SOIL dataset, and the five rotations listed in Table 15 were used for this purpose. Three possible crops precede potatoes in these five rotations: grain, hay, or potatoes. The comparisons are presented in Table 18. When hay is the preceding crop,

Table 17. Effect of Rotation on the Yield and Quality of Potatoes, 4VAR-7SOIL Dataset, FARMS, 1982.

Rotation	Number of Plots	Yield—cwt. Gross		Yield—cwt. US-1&2		US-1&2 Pct		Specific Gravity
PG	88	303	b	210	c	71	b	1.072
PPGH	25	345	a	262	a	77	a	1.072
PPG	93	330	ab	250	ab	77	a	1.074
PPPG	17	340	ab	253	ab	75	ab	1.074
P	40	328	ab	217	bc	69	b	1.074
								ns

Table 18. Effect of Previous Crop on the Yield and Quality of Potatoes, 4VAR-7SOIL Dataset, FARMS, 1982.

Previous Crop	Number of Plots	Yield—cwt. Gross		Yield—cwt. US-1&2		US-1&2 Pct	Specific Gravity
Hay	16	360	a	278	a	78	1.074
Grain	132	315	b	232	b	75	1.073
Potatoes	115	331	ab	239	b	74	1.073
						ns	ns

potatoes are actually preceded by grain-hay for two years during which potatoes are not grown (PPGH). When grain is the sole preceding crop, there is just one year in which grain replaces potatoes in the rotation (PG, PPG, PPPG). The data show that potatoes following grain or potatoes had lower yields than following hay. No significant effect of the previous crop on percentage US 1&2 or specific gravity was observed.

These data do support the use of rotations other than continuous potatoes (P). A review of the 1981 data indicates PG was equal to if not superior to PPGH. The 1982 data show a production advantage for PPGH. Based on both years, either PG followed by winter cover, or the PPGH rotation should: 1) maintain potatoes on the land 50 percent of the time, 2) reduce sheet and rill erosion, and 3) maximize potato yield and quality.

Soil Fertility

Nutrient analysis, pH, cation exchange capacity, and organic matter were measured on each of the 800 plots, Tables 19 and 20. The pH values were

Table 19. Summary Statistics for the Soil Test Nutrients in Pounds Per Acre, 800 Plots, FARMS, 1982.

Statistic	Ca	K	Mg	P	Al	B	Cu	Fe	Mn
Mean	1715	388	180	31	503	0.20	5.5	15	41
St. Dev.	1107	165	105	10	175	0.12	3.4	21	30
CV	65	43	58	31	35	60	62	145	73
Maximum	4840	1698	712	91	1064	1.09	18.3	454	282
Quart.-3	2100	450	244	38	612	0.24	7.6	16	51
Median	1413	372	159	31	506	0.17	5.1	11	33
Quart.-1	933	290	99	25	386	0.13	2.8	7	22
Minimum	95	44	8	3	6	0.00	0.0	1	7

Table 20. Statistics for Soil pH, Cation Exchange Capacity, Percent Saturation and Percent Organic Matter, 800 Plots, FARMS, 1982.

		Cation Ex. Cap.		Pct. Cation Sat.			Organic Matter
Statistic	pH	Act.	Pot.	Ca.	K	Mg	Percent
Mean	5.12	6.7	20.5	58.9	8.0	11.1	2.96
St. Dev.	0.48	2.4	4.0	19.4	3.6	5.7	0.80
CV	9	35	20	33	45	51	27
Maximum	7.2	14.3	34.2	95.4	27.8	30.0	7.34
Quart.-3	5.4	7.5	22.8	74.4	10.1	14.5	3.34
Median	5.1	6.1	20.8	60.5	7.9	10.0	2.89
Quart.-1	4.8	5.2	18.4	44.8	5.5	6.8	2.46
Minimum	3.7	2.7	3.9	7.1	0.5	0.9	1.14

Act.=Actual; P=Potential

slightly higher for 1982 than for 1981, and about 0.1 higher than reported for Aroostook County for the years 1958 and 1968 by Hepler and Hutchinson (9). The standard deviation for pH indicates a considerable spread of the individual plots, while the quartile data show that the central half of the plots range from pH 4.8 to 5.4. The pH, calcium, and percent calcium saturation of the base exchange complex all indicate that increased liming should result in better nutrient balance and higher levels of fertility. The potassium levels, while lower than were found for the 1980 plots, are still excessive. The magnesium, like the calcium, should be increased to achieve a better balance among the three major cations: calcium, potassium, and magnesium (12).

Removal of nutrients through soil erosion would not be expected to result in lowered yields. Since fertility levels are so high, the loss of nutrients adsorbed to eroding soil particles would have a negligible effect on crop yields.

CONCLUSIONS

The data for 1982 are generally similar to those collected in 1980 and 1981 (10,11). A drop in the estimated erosion, A, was observed from 1980 to 1981 to 1982 and no relationship of potato yield or quality to A was detected. The large variability in yields for all crops suggest an opportunity for many farms to improve yields. Conclusions are further stated in reference to specific questions posed under the objectives.

1. No significant general potato yield response to predicted levels of soil erosion was detected.
2. No significant responses to predicted soil erosion either of percentage US-1&2 or of specific gravity were observed.
3. Potatoes preceded by hay yielded better than potatoes preceded by grain or potatoes. Potatoes in the rotation with grain followed by hay, PPGH, yielded better than continuous potatoes, P, and better than different sequences of potatoes and grain PPPG, PPG, or PG.
4. Potato yields and quality were not significantly related to soils.
5. Thirty two soils were identified in the 1982 sample, Table 1. Caribou soil was found on 42 percent of the plots and Conant on 10. Thirteen soils each accounted for from 1 to 8 percent of the 1982 dataset, while the other 17 soils were each represented by 1 to 5 plots.
6. Differential fertilizer data have not yet been studied in detail. The soil test data show that pH is low, as are calcium and magnesium, potassium is excessive, and phosphorus is more than adequate. In general, erosion would not result in nutritional insufficiency unless there were drastic reductions in fertilizer applications.
7. Potato varieties, as expected, constitute a major source of variability not only for yield and for percent US-1, but also particularly for specific gravity.

LITERATURE CITED

1. Anonymous. 1979. A profile of Maine's soil and water resources from the national resource inventories, 1977. Phase I, land use and sheet and rill erosion. USDA-SCS, Orono, Maine.
2. Anonymous. 1980-83. Study of non-point agricultural pollution. USDA-SCS, Orono, Maine.
3. Anonymous. 1980. Study of non-point agricultural pollution. Central Aroostook Soil and Water Conservation District.
4. Anonymous. 1980. Technical guide data for estimating soil losses on cropland. USDA-SCS. , III-C-1. Orono, Maine.
5. Anonymous. 1981. Field procedures: field appraisal of resource management systems, FARMS. USDA-SCS, Orono, Maine.
6. Arno, John R. 1964. Soil survey of Aroostook County, Maine-northeastern part. USDA-SCS Series 1958, No. 27:1-80.
7. Arno, John R. 1964. Soil survey of Aroostook County, Maine-southern part. USDA-SCS Series 1961, No. 6:1-62.
8. Carpenter, P. N., 1953. Equipment and procedures in soil testing. Me. Agr. Exp. Sta. Misc. Publ. 623.
9. Hepler, P. R., and F. E. Hutchinson. 1971. Relation of sugar beet yields to lime and pH on a strongly acid Caribou soil. Research in The Life Sciences 19(2):1-12.
10. Hepler, P. R., L. H. Long and J. A. Ferwerda. 1983. Field appraisal of resource management systems FARMS, Crop yield and quality relationships with soil erosion 1980. Me. Agr. Exp. Sta. Bul. 799:1-30.
11. Hepler, P. R., L. H. Long, K. J. LaFlamme, and J. H. Wenderoth. 1984. Field appraisal of resource management systems FARMS, Crop Yield and quality relationships with soil erosion-1981. Me. Agr. Exp. Sta. Bul. 805:1-34.
12. McLean, E. O. 1977. Contrasting concepts in soil test interpretation: sufficiency levels of available nutrients versus basic cation saturation ratios. p. 39-54. In Peck, T. R., J. T. Cope, Jr. and D.A. Whitney (editors). Soil Testing: correlating and interpreting the analytic results. ASA Sp. Pub. No. 29.
13. Page, A. L., ed. 1982. Methods of soil analysis part 2, chemical and microbiological properties. Am. Soc. Agron. Madison, WI.
14. SAS Institute Inc. 1982. SAS user's guide: statistics, 1982 edition. SAS Institute Inc., Cary, NC.
15. Soil Survey Staff. 1951. Soil survey manual. U. S. Dept. of Agr. Handbook No. 18.
16. Wischmeier, W. H., and D. D. Smith. 1978. Predicting rainfall erosion losses-a guide to conservation planning. Agric. Handbook No. 537 USDA, Washington, D.C.